| Surname | | Other Names | |
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| Centre Number | | | Candidate Number | |
| Candidate Signature | | | |

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General Certificate of Education
January 2002
Advanced Level Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

# PHYSICS (SPECIFICATION A) PHA8/W
# Unit 8 Nuclear Instability: Turning Points in Physics Option

Monday 28 January 2002 Morning Session

**In addition to this paper you will require:**
- a calculator;
- a pencil and a ruler.

Time allowed: 1 hour 15 minutes

**Instructions**
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided. All working must be shown.
- Do all rough work in this book. Cross through any work you do not want marked.

**Information**
- The maximum mark for this paper is 40.
- Mark allocations are shown in brackets.
- The paper carries 10% of the total marks for Physics Advanced.
- A *Data Sheet* is provided on pages 3 and 4. You may wish to detach this perforated sheet at the start of the examination.
- You are expected to use a calculator where appropriate.
- In questions requiring description and explanation you will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary where appropriate. The degree of legibility of your handwriting and the level of accuracy of your spelling, punctuation and grammar will also be taken into account.

| For Examiner's Use | | | |
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**Data Sheet**

- A perforated *Data Sheet* is provided as pages 3 and 4 of this question paper.
- This sheet may be useful for answering some of the questions in the examination.
- You may wish to detach this sheet before you begin work.

**DATA SHEET**

**DATA SHEET**

**TURN OVER FOR THE FIRST QUESTION**

## SECTION A NUCLEAR INSTABILITY

Answer **all** parts of the question.

**1** (a) The nuclide $^{203}_{83}Bi$ can decay by *electron capture* to become an isotope of lead as shown in the following equation,

$$^{203}_{83}Bi + {}^{0}_{-1}e^{-} \longrightarrow {}^{203}_{82}Pb + \nu_e + Q.$$

(i) Explain what is meant by electron capture.

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(ii) Give **one** reason why electromagnetic radiation is emitted following this process.

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(iii) Give the equation for another process in which $^{203}_{83}Bi$ is converted into an isotope of lead.

$^{203}_{83}Bi \longrightarrow$

*(5 marks)*

(b) The nuclide $^{203}_{83}Bi$ is also an $\alpha$ particle emitter. An initial measurement of the $\alpha$ particle activity of a sample of this isotope gives a corrected count rate of 1200 counts $s^{-1}$. After an interval of 24 hours the corrected rate falls to 290 counts $s^{-1}$.
Assume that corrections have been made for the radiation both from daughter products and background radiation.

(i) Show that the decay constant of $^{203}_{83}Bi$ is about $1.6 \times 10^{-5} s^{-1}$.

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(ii) Calculate the half-life of this sample.

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(iii) Calculate the number of $^{203}_{83}Bi$ nuclei in the sample when the corrected count rate was 1200 counts $s^{-1}$.

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*(5 marks)*

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## SECTION B TURNING POINTS IN PHYSICS

Answer **all** questions.

**2** (a) Describe, with the aid of a diagram, an electromagnetic wave propagating through free space.

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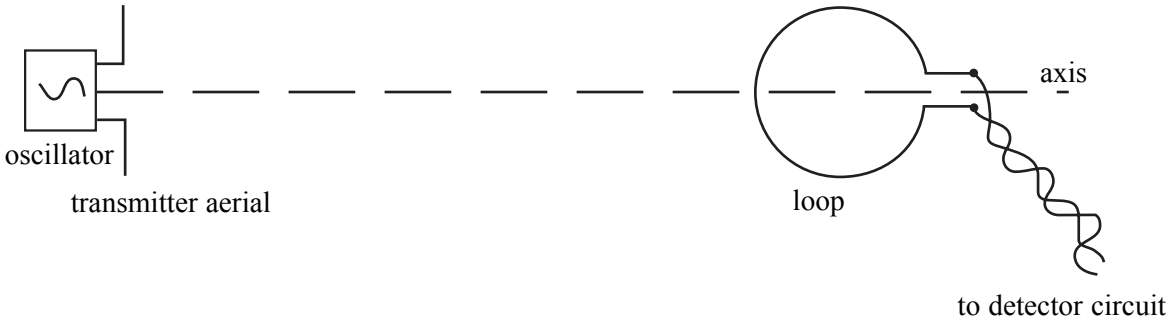
*(3 marks)*

(b) When an alternating potential difference of a suitably high frequency is applied to a transmitter, an alternating emf of the same frequency is induced in a detector loop as shown. The loop and transmitter aerial are in the same vertical plane.



(i) Explain, in terms of electromagnetic waves, why an emf is induced in the loop when in this position.

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(ii) The alternating emf decreases to zero when the loop is rotated about the axis through 90 ° until it is horizontal. Explain why the emf is zero when the loop is horizontal.

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*(4 marks)*

7

**3** (a) The speed of an object cannot be greater than or equal to the speed of light yet its kinetic energy can be increased without limit. Explain the apparent contradiction that the speed of an object is limited whereas its kinetic energy is not limited.

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*(3 marks)*

(b) Protons are accelerated from rest through a potential difference of $2.1 \times 10^{10}$ V.

(i) Show that the kinetic energy of a proton after it has been accelerated from rest through this potential difference is $3.4 \times 10^{-9}$ J.

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(ii) Show that the mass of a proton with the kinetic energy value calculated in part (a) is approximately $23\,m_0$, where $m_0$ is its rest mass.

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*(4 marks)*

(c) Calculate the speed of a proton which has a mass equal to $23\,m_0$.

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*(3 marks)*

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**TURN OVER FOR THE NEXT QUESTION**

**4** In an experiment to determine the charge on a charged oil droplet, the droplet was held stationary in a vertical electric field of strength 57 kV m$^{-1}$. After the electric field was switched off, the droplet fell at a steady speed, taking 18.3 s to fall through a vertical distance of 2.0 mm.

viscosity of air = $1.8 \times 10^{-5}$ N s m$^{-2}$,
density of the oil = 970 kg m$^{-3}$.

(a) Calculate the speed of the droplet when it was falling.

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*(1 mark)*

(b) Show that the droplet's radius was $9.7 \times 10^{-7}$ m.

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*(3 marks)*

(c) Calculate the charge of the droplet.

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*(3 marks)*

7

**5** (a) The anode voltage of a certain transmission electron microscope is 20 kV.

Calculate

(i) the speed of the accelerated electrons,

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(ii) the de Broglie wavelength of these electrons.

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*(4 marks)*

(b) State and explain how the image of an object observed using this transmission electron microscope in part (a) would change when the anode voltage was increased.

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*(2 marks)*

6

**END OF QUESTIONS**

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